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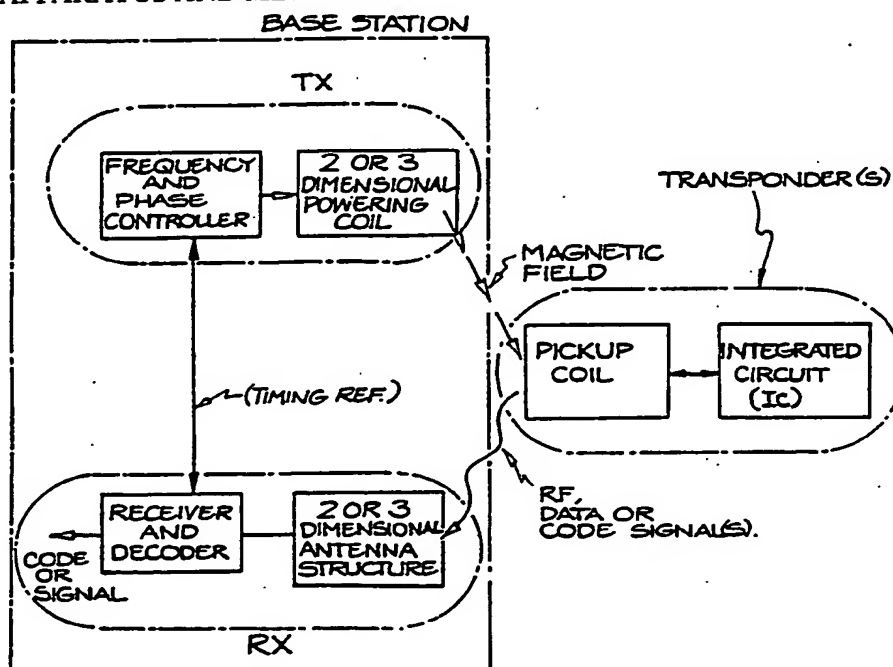
(57) Abstract

A transponder comprising: transponder receiver means adapted to extract powering energy from a surrounding electromagnetic field, transponder transmitter means adapted to transmit at least one unique signal from the transponder, frequency generating means for generating a plurality of predetermined frequencies, each frequency adapted to carry the signal from the transmitter means to an interrogator receiver means adapted to receive said signals to achieve indentification of said transponder. An identification system comprising: a transponder having means to extract powering energy from a surrounding electromagnetic field, and a transmitter means adapted to transmit one or more unique signals, and receiver means adapted to receive said signals and identify said transponder.

## IDENTIFICATION APPARATUS AND METHODS

### FIELD OF INVENTION

The present invention relates to a system of multiple device identification. The present invention further relates to a system utilising a plurality of remote devices and/or passive labels, the passive labels being adapted to extract energy from an applied magnetic field, the energy enabling transmission by the label of a signal, unique or coded, to be identified by a receiver, the remote devices being powered so as to transmit said signal, unique or coded. Each label or device can transmit simultaneously. Transmitting and receiving apparatus and methods of the system are also herein contemplated. The present invention in a preferred form is suitable for transponder (or a plurality thereof) identification.

### PRIOR ART

Conventional passive identification or transponder systems known to Applicant utilise a system in which a single common carrier frequency is used to transmit data or identification codes from and/or to each transponder. Simultaneous transmission by more than one transponder results in co-interference between the signals so transmitted and prevent correct identification of any of the transmitting transponders i.e. simultaneous transmission gives rise to corrupted signal(s).

Furthermore, the Applicant is aware of AU-A-70052/87 which describes a radio meter reading system that is designed to correctly read signals from several transponders simultaneously. The system utilises a "wake-up" signal from the interrogation station to activate a battery powered transmitter in each transponder. Data containing amongst other things the transponders ID and the meter reading modulates a transmitted carrier signal. The frequency of the transmitted carrier signal is randomly varied using a frequency control voltage derived from a digital pseudo-random generator. The transmitter is designed to keep these carrier frequencies within an allowed band.

The system disclosed is not capable of precisely controlling the carrier frequencies. Consequently, direct coherent detection of the transponder signals is not possible. Powering of the receiving circuitry for detecting the "wake-up" signal requires a battery or other external source of electrical power. Beyond the "wake-up" signal, there is no communication from the interrogator to the transponders.

Australian Patent AU-A-34109/84 discloses a transponder that transmits two or more carrier frequencies modulated with identical data. The carrier frequencies are either harmonics or sub-harmonics of the interrogation powering frequency. The specification is directed to the determination of correct data that has been transmitted when there is coincidence between the data on at least two of the carrier channels. With sufficient harmonic and sub-harmonic channels, external interference is unlikely to eliminate all of the transmitting channels.

This specification does not disclose a device capable of correctly interrogating more than one transponder simultaneously.

All transponders are constrained to transmit identical harmonic and sub-harmonic frequencies and will consequently interfere on all channels if and when two or more transponders are active. The harmonics are generated by a square wave derived from the interrogation signal. Square waves are rich in odd harmonics. There is no possibility of selecting any particular harmonic(s) for transmission, as all harmonics are generated and radiated by square waves.

OBJECT OF THE INVENTION

An object of the present invention is to provide a system wherein a plurality of devices may be simultaneously identified and/or a single device may also be identified.

A further object of the present invention is to provide a system which may be specifically designed to identify devices within an acceptable failure rate criterion.

A further object of the present invention is to provide a system having minimal co-interference and wherein a plurality of devices may be correctly identified by a single receiver even if the devices are in close proximity.

A further object of the present invention is to provide a multiple transponder identification system, each transponder therein being implemented in a single (IC) chip form.

Another object of the present invention is to provide a system adapted to identify many objects such as personnel, livestock, baggage, packages, cargo, stolen goods, vehicles, trains, wagons, shipping containers, security cards and may be used in environments requiring identifying or interrogating capabilities, such as inventory control and computer security.

Another object of the present invention is to provide a system wherein any one or all device(s) and/or transponder(s) therein can be interrogated or altered in response to a radiated magnetic field.

Another object of the present invention is to provide a system comprising disposable and cheap transponders or labels.

SUMMARY OF INVENTION

The present invention provides a system of device identification comprising :

at least two spaced identifiable device and a device identifier wherein :

each identifiable device comprises means forming transmitter means, means forming a device identification code and modulation means, said modulation means and code means being adapted to drive said transmitter means so that said device identification code is transmitted and identified by said device identifier.

The present invention provides a system of multiple transponder identification comprising :

- 4 -

at least two transponders, a magnetic power field generator/radiator and a transponder identification code receiver, wherein

each transponder comprises receiver/transmitter means including an inductive means adapted to simultaneously receive power to operate the transponder and transmit coded modulated signal(s), memory means for storing an identification code, modulation means and control means, said receiver/transmitter means and memory means being adapted to jointly co-operate with said modulation means, when each transponder is under the influence of said power field to transmit an identification code unique to each transponder to said code receiver,

the control means, being adapted to co-ordinate operation of said memory, modulation and receiver/transmitter means, and wherein

the code receiver receives each unique code and identifies each respective transponder.

The present invention in another aspect provides a transponder comprising :

transponder receiver means adapted to extract powering energy from a surrounding electromagnetic field,

transponder transmitter means adapted to transmit at least one unique signal from the transponder,

frequency generating means for generating a plurality of predetermined frequencies, each frequency adapted to carry the signal from the transmitter means to an interrogator receiver means adapted to receive said signals to achieve identification of said transponder.

The present invention provides an identification system comprising :

a transponder having means to extract powering energy from a surrounding electromagnetic field, and a transmitter means adapted to transmit one or more unique signals, and

receiver means adapted to receive said signals and identify said transponder.

The present invention also provides an identification system incorporating a transponder as described above.

The present invention also provides an identification system comprising :

a plurality of transponders, each transponder having means to extract energy from a surrounding electromagnetic field and transmitter means adapted to transmit at least one unique signal at at least one frequency selected from a plurality of predetermined frequencies, and

receiver means adapted to receive each of said unique signals and identify said transponder.

The present invention further provides a system for simultaneously identifying a first and second label, each label comprising code storage means, modulation means and an inductive receiver/transmitter means, the system comprising :

magnetic field generator/radiator means for generating a magnetic field from which said first and second labels are adapted to extract power using said inductive means,

each of said first and second labels, when so powered, respectively providing at least one unique code from the code storage means to the modulation means, said modulation means being adapted to provide at least one modulated code to the inductive means for transmission to a label identifying receiver,

each label adapted to modulate said at least one code onto at least one carrier frequency randomly selected from a predetermined finite set of modulation frequencies,

each label being further adapted to re-transmit its said at least one code at another or the same at least one frequency randomly selected from said set of frequencies while each label remains powered,

each label being embodied in a single (IC) chip.

The present invention also provides an identification system comprising :

a transponder adapted to transmit at least one data signal at at least one carrier frequency selected from a plurality of carrier frequencies, said transponder including control means for selecting said at least one selected frequency and, when the data has been transmitted, for re-selecting the or another at least one selected carrier frequency from the plurality of carrier frequencies in accordance with a predetermined probability weighting, the transponder being adapted to continue transmitting the data at the or another at least one selected frequency while the transponder is powered, and receiver means adapted to receive the or said another at least one frequency including demodulator means for obtaining the data.

The present invention further provides an identification system comprising :

a first and a second transponder, said transponders being adapted to continuously transmit respective first and second data signals while each transponder is powered, the first and second data signals having a first and a second respective carrier frequency selected from respective first and second predetermined sets of possible carrier frequencies, said first and second transponders including respective first and second selector means for selecting the first and the second respective carrier frequency from said respective sets of frequencies,

receiver means for receiving the first and second data signals simultaneously,

demodulator means for demodulating the first and second data signals at their respective carrier frequency to obtain a first and second respective transponder identifying code.

The system may further comprise comparison means adapted to disregard corrupted transponder or label codes or signals.

The signal(s) may be at a radio frequency or at any other frequency.

The random selection of carrier or modulation frequency(s) provides improved resistance to interference between labels.  Co-interference of labels may be statistically ignored by the identifying receiver.

Each transponder may continue to transmit its transponder identification code while under the influence of the generator or while being powered.

Each transponder may include at least one transmission break during which its transponder identification code is not transmitted.

The transponder identification code receiver may comprise demodulation means adapted to identify each transponder.

The present invention provides for the use of a passive coil label to extract energy from a surrounding applied field and the re-transmission by the passive label of a unique signal to be picked up by a receiver.

Reference herein to transponder(s) or label(s) should be read so as to include any other suitable device.

The present invention will now be described with reference to the accompanying drawings, wherein :

Figures 1A and 1B show an identification system in accordance with the present invention.

Figures 2A, 2B, 3A, 3B and 4A, 4B show embodiments of a transponder suitable for use in the present invention.

Figure 5 shows a circuit for generating the transponder carrier signal.

Figures 6 and 7 show alternative embodiments capable of generating a plurality of carrier frequencies.

Figures 8A and 8B show two circuits for transmitting two or more modulated carrier signals simultaneously and independently of each other.

Figure 9 shows a schematic of a coherent receiver.

— 8 —

Figures 10A and 10B show two circuits for envelope shaping the modulated carrier signal to reduce sideband interference between channels.

Figures 11 and 12 show modulation detection circuits.

The or each, transponder may be embodied in a single (IC) chip form. An external capacitor may be used to store the chip operating voltage. The receiver/transmitter inductive means, preferably a single coil, may also be mounted externally to the chip.

With reference to Figures 1A and 1B, the base station may include a transmitter for generating an ultrasonically oscillating magnetic field. The transponder(s) may contain a tuned pickup coil which may extract power and/or timing and/or other information from the magnetic field. The frequency, magnitude and phase of the magnetic field generated by the base station may be carefully controlled to enable the power picked up by the transponder coil to be adequate for most transponder orientations. A magnetic field radiated in two or three dimensions will aid power and information reception by the transponder(s). Identification codes and/or specially stored or other information may be transmitted from the transponder to a receiver in the base station, conventionally, by an RF or other suitable signal. Programming and/or interrogation of temporary or permanent memory on one or more transponder(s) may be performed conventionally, for example by modulation of the powering field. Concatonated coil(s) may be used to maintain field intensity in a predetermined space through which the transponder(s) will move. Magnetic field concentrator(s) may be used to amplify field intensity.

Furthermore, the transponder(s) may generate one or more carrier frequencies from an available set of carrier frequencies. These carrier frequencies are preferred not to be harmonically related to the frequency of the powering

magnetic field.  By allowing each transponder to use any one
of a multiplicity of available carrier frequencies, many
transponders simultaneously transmitting to the base station
may be identified under conditions where co-interference
would normally preclude correct identification.  Ensuring
correct identification may be enhanced by reducing the
possibility of more than one transponder simultaneously
transmitting at the same frequency.  An idle state, during
which a transponder does not transmit, may aid correct
identification.  The number of carrier frequencies and idle
states may be contingent upon the particular application.
The correct identification of a transponder may be reliant
upon the transponders having a carrier frequency or mix of
carrier frequencies, free of interference by other
transponders, to transmit on.  The particular mix of carrier
frequencies, idle states and probability weightings may be
chosen to maximise the probability of any one transponder
having a free channel to transmit, to a receiver, its
identification code word.  Inclusion of redundant frequency
channels may guard against the possibility of chance
transponder interference.  Signals which may have been
corrupted or co-interfered with may be ignored by the
receiver, and may thereby enable the system to operate
within a predetermined failure rate criterion.  Corrupted or
co-interfered signals may be determined on a statistical
basis or by means of an error detecting code.  The
transponder(s) may transmit the identifying code at a
randomly selected frequency(s), selected from a set of
available carrier frequencies, and, once transmission is
completed, again re-transmit the code at the same or another
frequency(s) selected from the carrier frequency set.  The
identifying code may be used to modulate the selected
frequency(s).

    The system of transponder identification according
to the present invention may allow for identification of a
number of objects by a uniquely coded transmission from a

- 10 -

passive transponder or label attached to each object,
identification occurring at substantially the same time.

With reference to Figures 2A, 2B, 3A, 3B, 4A and
4B, power, preferably in the form of a magnetic field, may
be transmitted inductively or radiated to the transponder.
Each transponder may include one or more pickup or receiver
transmitter coils or inductive means. To minimise
detailing, further reference herein is made to only single
coiled transponder(s). A pickup coil, preferably tuned, may
be situated in the transponder to collect or receive the
power. After rectification, the power may be utilised by an
integrated circuit (IC) within the transponder. The
frequency of the powering signal may be used as a universal
frequency reference for both the IC and the base station
(Figure 1A). Alternatively, an oscillator in the base
station may serve as a universal timing reference for the
powering signal, base station receiver and transponder IC
(Figure 1B). The transponder IC derives its frequency
reference from the powering signal (Figures 2A, 2B, 3A, 3B,
4A and 4B). Each transponder may be controlled and/or
programmed by modulating the inductive powering field. This
modulation may enable data or commands to be transmitted to
one or more transponder(s). This modulation may be used,
for example, to program data into the transponder, set
bit(s) in the transponder which may control the
transponder's function e.g. a bit to disable transmission
permanently when the transponder is discarded, or control
the transponder's activity while it is being inductively
interrogated e.g. forcing a change in the transponder's
carrier frequency, or generally controlling and/or
interrogating other transponder units or functions.

To ensure that the transmission of power and/or
signal(s) is as uniform as possible, a two, or if necessary,
a three dimensional antenna system may be used. An antenna
structure at the base station may receive the transponder's
coded carrier transmission. With regard to the IC of a

transponder, it may generate one or more non-harmonically
related carrier signals from the frequency of the powering
field.  The method of generating these carrier signals will
be explained further on.

5       The carrier signals generated by the IC are phase
locked to the powering signal.  The powering signal is
derived from a master oscillator in the base station.
Coherent locking of the carrier signals allows direct
coherent demodulation of the coded carrier signal by the
10  receiver and demodulator in the base station.  Coherent
detection is the optimum detection scheme for coded carrier
signals.  The frequency of the powering field or a carrier
signal divided down may be utilised as a clocking signal for
the IC.  A unique code, preset, programmed or selected in
the IC may be used to modulate the carrier signal at a rate
15  determined by the clocking signal.  The modulator may
produce a modulated RF signal using, typically, phase
modulation, amplitude, pulse width, pulse position or other
modulation.  This code modulated signal may be injected into
the transponder pickup coil for inductive transmission to a
20  receiving antenna structure.

The signal(s) received from one or more
transponder(s) may be amplified and coherently detected,
using a local oscillator locked on to the powering field's
frequency or preferably the base stations master time
25  reference oscillator.  A multiplicity of coherent detection
schemes may be used to detect the received signal(s), all of
which are known to those skilled in the art of
communication.  For example, direct homodyne detection of a
transponder carrier may be possible using a local oscillator
30  locked to the transmitted powering field's frequency (Figure
9).  The power field's frequency may be used as a universal
timing reference.  For a preferred modulation scheme (phase
modulation), optimum detection may be realised using
correlators locked to the powering field's frequency.
35  Either a frequency agile receiver or a multiplicity of

receivers may be tuned to the different possible carrier
frequencies contained within the set of carrier frequencies
to receive the transmitted signal from the transponder(s).

For those applications where the orientation of the
transponder may be random, such as baggage and livestock
identification, special antenna structures may be necessary
such that the voltage picked up by the transponder(s) coil,
which may be dependent upon the cosine of the angle between
the transponder coil axis and the direction of the magnetic
field, is preferably substantially constant over a large
volume of space, and so that rapidly moving transponders may
be satisfactorily identified. Ideally, the power
transferred to each transponder coil should be independent
of transponder orientation.

To provide an isotropic powering field three sets
of coils may be orientated along the X,Y and Z axes. The
phase and frequency used to drive these coils may be
carefully controlled to generate an isotropic powering field
and provide a uniform field over a substantial volume of
space. Two coils may alternatively be used.

The data transmitted from the transponder may be
received by loop antennae set up in two or three dimensions
or axes. The data signals from each axis may be detecting
separately and may be combined for decoding or decoded
separately.

Interference may be cancelled by mounting a set of
"interference coils" in proximity of the transponder(s) data
or signal receiving coils. The signal from the interference
coil may be subtracted from the receiver signal cancelling
any interference. Cancellation may be done at the carrier's
frequency.

By having one or more transponder(s) select,
preferably randomly, from a plurality of possible
transmission frequencies, and/or by utilising one or more
transmission break(s), during which no transmission from at
least one transponder is made, or a combination of these,

the simultaneous identification of a plurality of transponders may be possible. Each transponder in the system of the present invention, when powered, may begin to transmit its code or other information. This transmission
5   may be continuous while the transponder is powered. The transmission may be based on a preferably randomly selected frequency(s), from a possible set of frequencies, or transmission breaks.

A method, of identification for use in a system as
10  described hereinbefore, the system being adapted for any system designed to identify transponder(s) or labels; may include an acceptable failure rate criterion. The correct identification of each transponder may require that each transponder has at least one complete code or data word
15  transmission free of interference from other transponder(s).

For a transponder to be correctly identified it only requires one good read during an interrogation cycle. Alternatively, for the transponder to not be identified requires that all reads are bad, i.e. P (at least one good
20  read) = 1 - P (all reads are bad).

Probability that a read is good requires that no other transponder is using the same carrier frequency, if there are "m" transponders and "n" channels and each transponder's transmissions are independent of all other
25  than this probability is :

$$\left(\frac{n-1}{n}\right)^{2(m-1)}$$

hence the probability that a transmission is bad is :

$$1 - \left(\frac{n-1}{n}\right)^{2(m-1)}$$

and the probability that of k code transmissions all are bad

30  is $\left(1 - \left(\frac{n-1}{n}\right)^{2(m-1)}\right)^k$

This is the probability that a particular transponder will fail to be identified during an interrogation cycle.

- 14 -

By carefully choosing the number of carrier
frequencies available to a transponder and/or the
availability of a transmission break, the system's failure
rate may be matched to the acceptable failure rate.

5        A carrier generator in each transponder or label
may generate carrier frequency(s) for use by the modulation
means. The carrier frequency(s) may be generated by one or
more voltage controlled oscillators (VCO's) which may be
phase locked to the frequency of the inductive powering
10      field. The output carrier frequency may equal $(p + \frac{n}{m})$ x
(frequency of inductive power field); where p is a harmonic
of the powering field's frequency and the ratio $\frac{n}{m}$ is not an

integer (Figures 5 and 6). A circuit for generating the
15      carrier frequency is shown in Figure 5. The circuit is a
phase locked loop (PLL) incorporating a frequency divider in
the feedback loop. This type of circuit is well known and
acts as a frequency multiplier with the output frequency of
the VCO (or other similar controlled oscillator) equal to
20      the divider magnitude :
         frequency VCO = (pm+n) x frequency time reference.
         The VCO output frequency will always be a harmonic
of the powering field and potentially would be prone to
interference from the field's harmonics. Dividing the VCO
25      output by "m" changes the output frequency such that only
every $m^{th}$ carrier frequency coincides with a power field
harmonic. In the preferred embodiment these frequencies are
not utilised by the transponder. Consequently, the powering
field's harmonics may never interfere with the carrier
30      transmissions.
         A further advantage of this method of phase
coherent carrier generation is that a similarly generated
local oscillator signal at the base station can be used to
coherently detect and demodulate the carrier signal(s).
35      This oscillator can be phase locked to the powering field

(like the transponder carrier oscillator) or in its preferred form to a master time reference oscillator from which the power field's frequency is derived. Direct homodyne detection of the carrier can be done using identical frequency generating parameters n, m and p as used by the transponder carrier oscillator. Alternatively the carrier signal can be converted to an intermediate frequency (IF) before detection. These coherent detection principles are widely utilised and well understood.

The present invention may provide a system in which control of the selection of a carrier frequency(s) and/or transmission break(s) may be accomplished. Varying degrees of complexity may be implemented by the selection circuitry. In one embodiment, a pulse of modulation, on the powering field, may cause any affected transponders to randomly select a carrier frequency or transmission break. By appropriate coding of this modulation of the powering field, coupled with suitable detection and decoding circuitry on each transponder, more elaborate selection schemes such as, turning off a particular transponder's transmission, forcing some or all transponders off a channel(s), or changing a particular transponder's channel may be implemented. Frequency, phase, amplitude or pulse modulation or any combination of these can be used to modulate the magnetic powering field.

For an arbitrarily modulated oscillating magnetic field, the data rate may be limited by the bandwidth of the transponder's antenna. This may be sufficiently large to allow a data rate of any required number of kilobits per second.

Preferably, the magnetic field may be phase or frequency modulated because these may not appreciably affect the power transmission from the transmitter to the receiving unit. Amplitude, pulse width or pulse position modulation may also be used. Figures 11 and 12 show circuits for detecting this modulation.

– 16 –

The simultaneous action of power transfer and data or command transmission by a magnetic field may allow the remote control of electro-mechanical devices and/or electronic circuits and the remote programming of $E^2$ PROM or conventional CMOS memory with battery backup in a manner similar to that as detailed herein.

Arbitrary probability weightings of selection may also be assigned to each carrier frequency and/or idle state. Alternatively, a transponder may randomly select either a transmission break or carrier frequency. The carrier frequency of the transponder may be altered after each completed code or data word transmission or the transmission of more than one code or data word before reselecting the carrier frequency.

The system may also provide for the simultaneous transmission of more than one carrier frequency by any transponder. Transmission of more than one carrier can be used to increase the communication reliability or to increase the rate of data transmission. Different sets of data or unique signals can be transmitted on different carrier frequencies. A transponder may select a subset of carrier frequencies from the full set of available carrier frequencies. The exact number of carriers transmitted, the size of the full set of carrier frequencies and the method of selection i.e. whether controlled or by random internal selection, would depend upon the particular transponder's application.

It has been shown mathematically, that in a system of "m" labels, each randomly choosing one out of "n" distinct radio channels before each transmission, if a total of "k" transmissions are possible (by any one label) within the available time, the probability of one or more labels failing to be identified, is given by

$$\left( 1 - \left( \frac{n-1}{n} \right)^{2(m-1)} \right)^{k}$$

The use of certain, inherently random, natural processes (to generate the random numbers used here to select the transmitting channel), is well known. Examples used in practical equipments include radioactive decay processes, and the so-called "shot noise" generated by quantum mechanical processes within semiconductor diodes.

These processes are, however, somewhat awkward to implement on a semiconductor, VLSI, "chip". The noise-diode approach, in particular, suffers from the risk that the "noise" signal (which is at a low amplitude) will be contaminated by other, stronger electrical signals present on the chip. This could seriously impair the statistical properties of such a signal.

The use of a "Pseudo-Random Binary Sequence" (PRBS) generator, in digital systems, is well known. The device typically comprises a digital shift register (built using any known method), associated with a computing means (typically an arrangement of logical gate circuits), which generates a binary, logical function of the shift register's contents. This value is applied to the serial input of the shift register. As the shift register is clocked, a new binary number appears in the several "bits" of the register.

With a careful choice of register length, and of the mathematical function generated by the said computing means (the "feedback function"), it is possible to generate a sequence having as many as $2^N - 1$ distinct values (a so-called maximal-length, or "M-" sequence) using a N-bit shift register. Such a sequence can exhibit mathematical properties closely approximating a true, random sequence.

On the face of it, such a device is inherently unsuitable for the present purpose. The reason is that, when the label is first excited by the powering magnetic field, there is no means to determine what will be the

initial contents of said shift register.  In practice, the
initial value will almost always be a constant value,
identical for every label.  (The value will be a function of
the physical circuit layout on the VLSI chip.  This, of
course, is the same for every label).

In such a case, every label being initially started
at the same number, the feedback function will reproduce
identically in every label, and they will continually
transmit on the same channel.  This defeats the purpose of
the system.

A simple modification permits the use of a PRBS
generator (so gaining its acknowledged advantages of
inherent suitability for VLSI implementation), but avoids
the problem aforementioned.

Recall that the labels contain, inter alia, a
"memory means" to record their identification codes.  Let
this memory means be expanded sufficiently to store, besides
said identification code, a further number, having as many
bits as has the PRBS shift register.  Let the control
circuitry in the label be so adapted that, whenever the
label is first excited by the powering field (i.e. its logic
circuitry "starts up"), this additional number is loaded
into said PRBS register.  This number being loaded, the PRBS
generator operates as described.

Let further, the associated programming means (the
equipment which initially stores the identification code in
said memory means) be further adapted to store also, a
randomly generated number (another PRBS circuit would
suffice here) in the additional memory space aforementioned.

With a total of "N" binary bits in the PRBS
register, we have now a 1 in $2^N-1$ chance that two labels
will start up at the same point in their PRBS sequences.  In
that event, the system will fail, since these two will
always "track" each other.  With a target value for system
reliability determined, this rule fixes a minimum length for
the PRBS generator.  Commonly, the PRBS register will be

given a length equal to the next prime number, larger than the size found above.

The PRBS system is particularly effective, if both the number of bits, N, in the register, and the number of PRBS states, $2^N-1$, are both prime. In this case, however many times the register is shifted between channel selections, all possible states will be exhausted before the cycle repeats. An example of such a PRBS circuit comprises a 17-bit register, with the feedback function comprising an exclusive-OR of the 14th and 17th bits. The numbers 17 and 131071 are both prime.

It is desirable that the register should be shifted, between channel selections, a number of places greater than its own length. This ensures that the "randomising" process has been applied to every bit in the register. Any desired subset of the register bits may be used to effect the channel selection.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1.        A transponder comprising :
          transponder receiver means adapted to extract
powering energy from a surrounding electromagnetic field,
          transponder transmitter means adapted to transmit
at least one unique signal from the transponder,
          frequency generating means for generating a
plurality of predetermined frequencies, each frequency
adapted to carry the signal from the transmitter means to an
interrogator receiver means adapted to receive said signals
to achieve identification of said transponder.

2.        A transponder as claimed in Claim 1, further
comprising
          control means for selecting at least one selected
frequency from the plurality of predetermined frequencies,
said selected frequency(s) being used as carrier(s) for said
unique signal.

3.        A transponder as claimed in Claim 2, wherein
          the control means re-selects the or another at
least one selected frequency from the plurality of
predetermined frequencies for retransmission of said unique
signal.

4.        A transponder as claimed in Claim 2 or 3, wherein
the selection or the reselection is performed in accordance
with a predetermined probability weighting.

5.        A transponder as claimed in Claim 3, wherein said
transponder continues to retransmit said unique signal while
the transponder is powered.

6.      A transponder as claimed in Claim 2 or 3, wherein
the control means uses a pseudo-random binary sequence
(PRBS) logic circuit to randomly select said selected
frequency(s).

7.      A transponder as claimed in Claim 6, wherein the
PRBS is adapted to have an initial value loaded therein when
the transponder is first powered, the value being stored in
a memory in the transponder.

8.      A transponder as claimed in Claim 7, wherein the
unique code and value are arbitarily assigned to the
transponder before use of the transponder.

9.      An identification system incorporating a
transponder as claimed in any one of Claims 1 to 8.

10.     An identification system comprising :
        a transponder having means to extract powering
energy from a surrounding electromagnetic field, and a
transmitter means adapted to transmit one or more unique
signals, and
        receiver means adapted to receive said signals and
identify said transponder.

11.     An identification system comprising :
        a plurality of transponders, each transponder
having means to extract energy from a surrounding
electromagnetic field and transmitter means adapted to
transmit at least one unique signal at at least one
frequency selected from a plurality of predetermined
frequencies, and
        receiver means adapted to receive each of said
unique signals and identify said transponder.

- 22 -

12.      An identification system as claimed in Claim 11,
wherein each of said unique signals is received
simultaneously.

13.      An identification system as claimed in Claim 11,
wherein the receiver means includes logic means adapted to
ignore incoming unique signals having the same selected
frequency.

14.      An identification system as claimed in Claim 11,
wherein the receiver means is synchronized to the frequency
of the electromagnetic field to facilitate demodulation of
each unique signal.

15.      A system of device identification comprising :
         at least two spaced identifiable devices and a
device identifier wherein :
         each identifiable device comprises means forming
transmitter means, means forming a device identification
code and modulation means, said modulation means and code
means being adapted to drive said transmitter means so that
said device identification code is transmitted and
identified by said device identifier.

16.      A system of multiple transponder identification
comprising :
         at least two transponders, a magnetic power field
generator/radiator and a transponder identification code
receiver, wherein
         each transponder comprises receiver/transmitter
means including an inductive means adapted to simultaneously
receive power to operate the transponder and transmit coded
modulated signal(s), memory means for storing an
identification code, modulation means and control means,
said receiver/transmitter means and memory means being
adapted to jointly co-operate with said modulation means,

when each transponder is under the influence of said power
field, to transmit an identification code unique to each
transponder to said code receiver,

the control means being adapted to co-ordinate
operation of said memory, modulation and
receiver/transmitter means, and wherein

the code receiver receives each unique code and
identifies each respective transponder.


17.      A system as claimed in Claim 16, wherein each
transponder is embodied in a VLSI chip.


18.      A system for simultaneously identifying a first and
second label, each label comprising code storage means,
modulation means and an inductive receiver/transmitter
means, the system comprising :

magnetic field generator/radiator means for
generating a magnetic field from which said first and second
labels are adapted to extract power using said inductive
means,

each of said first and second labels, when so
powered, respectively providing at least one unique code
from the code storage means to the modulation means, said
modulation means being adapted to provide at least one
modulated code to the inductive means for transmission to a
label identifying receiver,

each label adapted to modulate said at least one
code onto at least one carrier frequency randomly selected
from a predetermined finite set of modulation frequencies,

each label being further adapted to re-transmit its
said at least one code at another or the same at least one
frequency randomly selected from said set of frequencies
while each label remains powered,

each label being embodied in a single (IC) chip.

19.      An identification system comprising :

a transponder adapted to transmit at least one data
signal at at least one carrier frequency selected from a
plurality of carrier frequencies, said transponder including
control means for selecting said at least one selected
frequency and, when the data has been transmitted, for
re-selecting the or another at least one selected carrier
frequency from the plurality of carrier frequencies in
accordance with a predetermined probability weighting, the
transponder being adapted to continue transmitting the data
at the or another at least one selected frequency while the
transponder is powered, and receiver means adapted to
receive the or said another at least one frequency including
demodulator means for obtaining the data.

20.      An identification system comprising :

a first and a second transponder, said transponders
being adapted to continuously transmit respective first and
second data signals while each transponder is powered, the
first and second data signals having a first and a second
respective carrier frequency selected from respective first
and second predetermined sets of possible carrier
frequencies, said first and second transponders including
respective first and second selector means for selecting the
first and the second respective carrier frequency from said
respective sets of frequencies,

receiver means for receiving the first and second
data signals simultaneously,

demodulator means for demodulating the first and
second data signals at their respective carrier frequency to
obtain a first and second respective transponder identifying
code.

21.      An identification system as claimed in Claim 18, 19
or 20, further comprising comparison means adapted to
disregard corrupted transponder or label codes or signals.

22.      A system as claimed in Claim 18, 19 or 20, wherein
the transponder or label power is provided by an
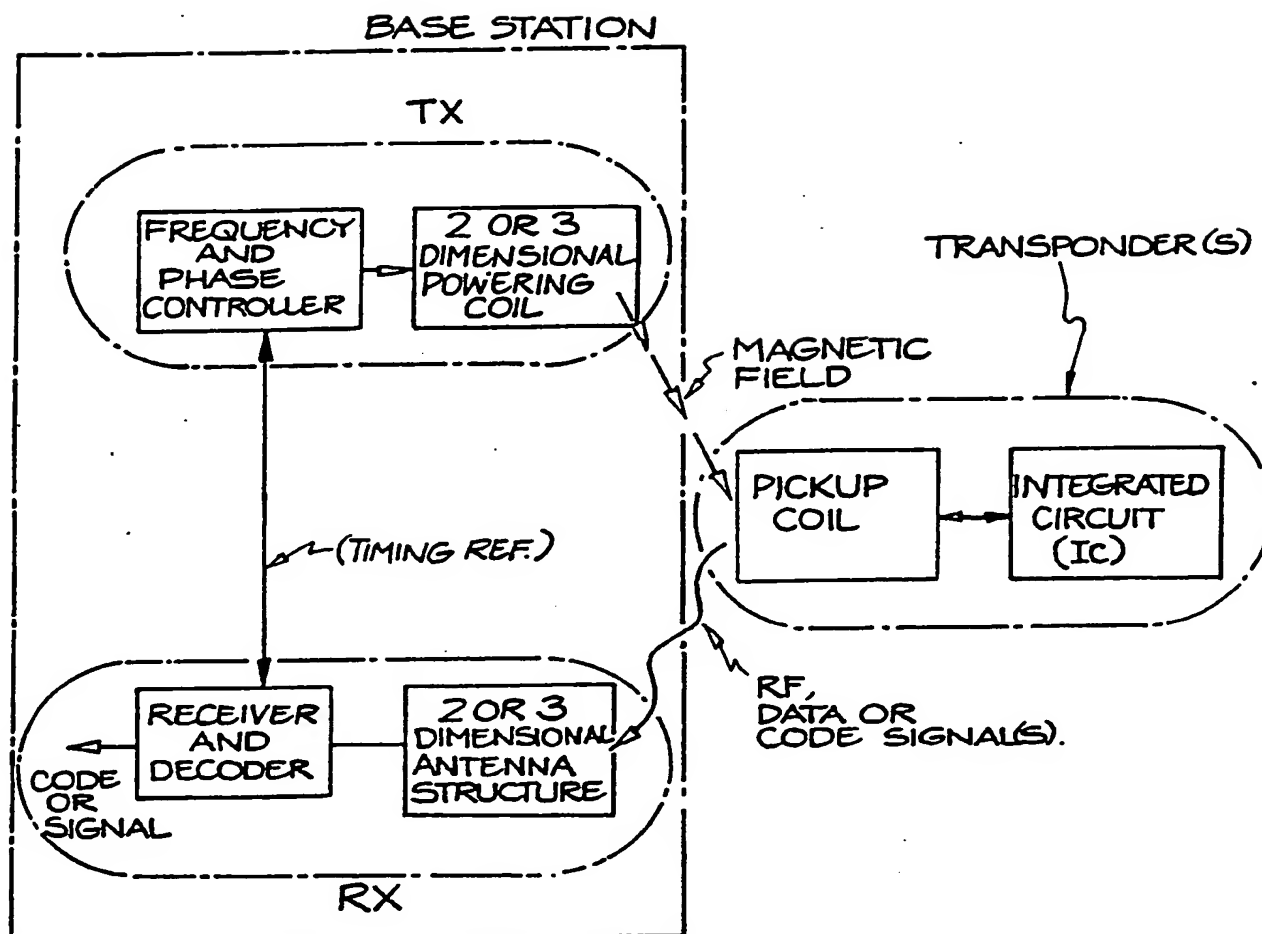electromagnetic powering field.

23.      A system as claimed in Claim 22, wherein the at
least one selected carrier frequency is phase coherently
generated using the powering field as a frequency reference.

24.      A system as claimed in Claim 23, wherein the at
least one carrier frequency is generated using at least one
phase-locked loop frequency multiplier, and subsequently
divided to obtain a desired carrier frequency.

25.      A system as claimed in Claim 24, wherein
frequencies generated which correspond to harmonics of the
powering field are ignored.

FIGURE.1A

BASE STATION

TX

FREQUENCY AND PHASE CONTROLLER

2 OR 3 DIMENSIONAL POWERING COIL

MAGNETIC FIELD

TRANSPONDER(S)

PICKUP COIL

INTEGRATED CIRCUIT (IC)

(TIMING REF.)

RECEIVER AND DECODER

2 OR 3 DIMENSIONAL ANTENNA STRUCTURE

RF, DATA OR CODE SIGNAL(S).

CODE OR SIGNAL

RX

FIGURE.1B

BASE STATION

TX

FREQUENCY AND PHASE CONTROLLER

2 OR 3 DIMENSIONAL POWERING COIL

MASTER TIME REFERENCE

(TIMING REF.)

MAGNETIC FIELD

TRANSPONDER (S)

PICKUP COIL

INTEGRATED CIRCUIT (IC)

RECEIVER AND DECODER

2 OR 3 DIMENSIONAL ANTENNA STRUCTURE

CODE OR SIGNAL

RF, DATA OR CODE SIGNAL(S).

RX

FIGURE.2A

FIGURE.2B

FIGURE. 3B

FIGURE. 3A

FIGURE. 4A

FIGURE. 4B

FIGURE.5

SINGLE OSCILLATOR WITH
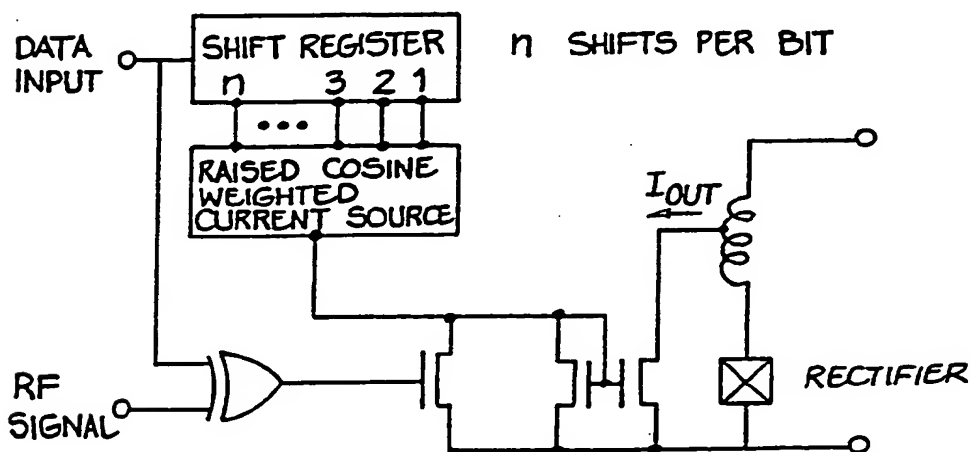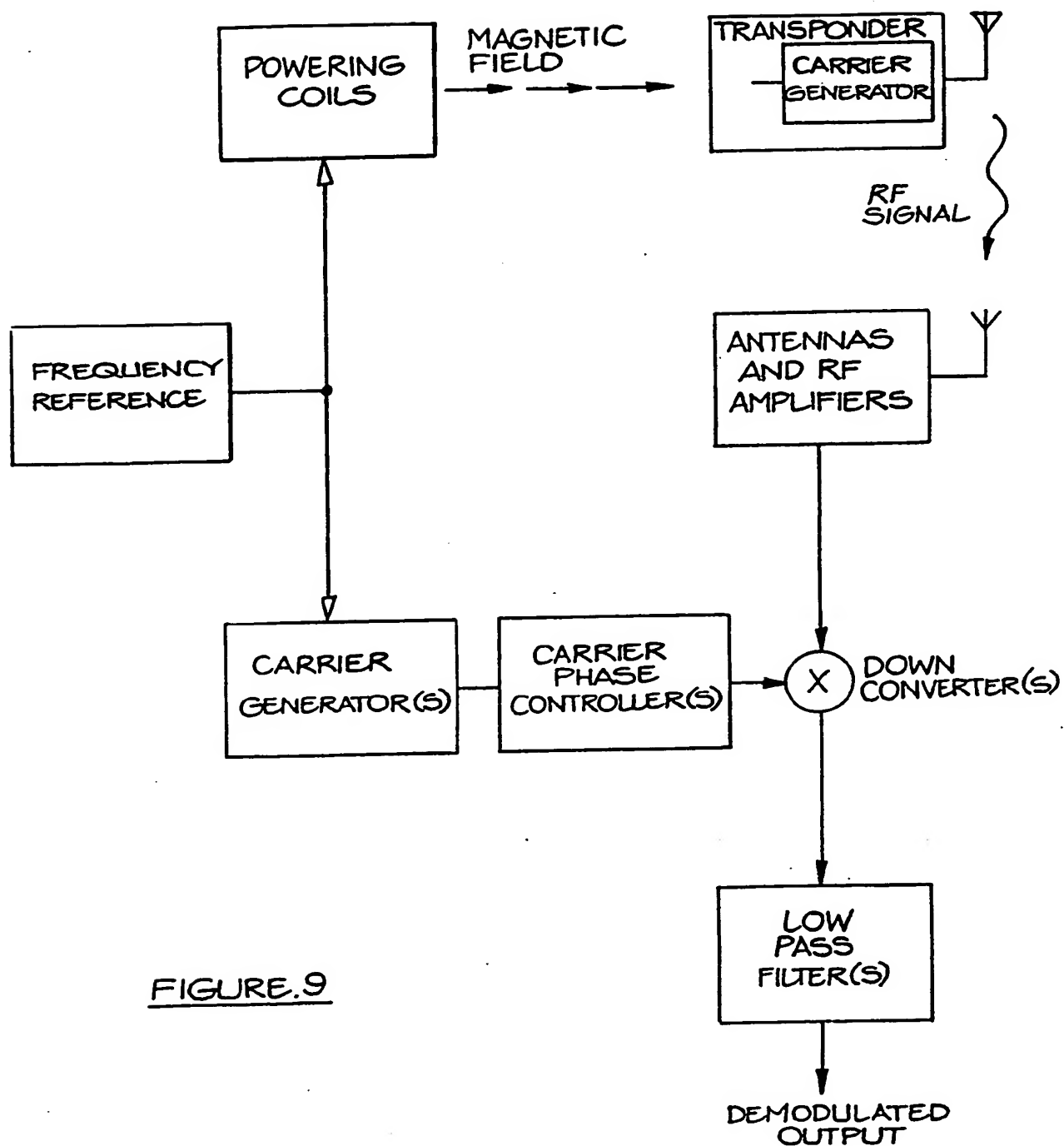SETTING OF CARRIER FREQUENCY
PERFORMED BY CHOOSING 'n'
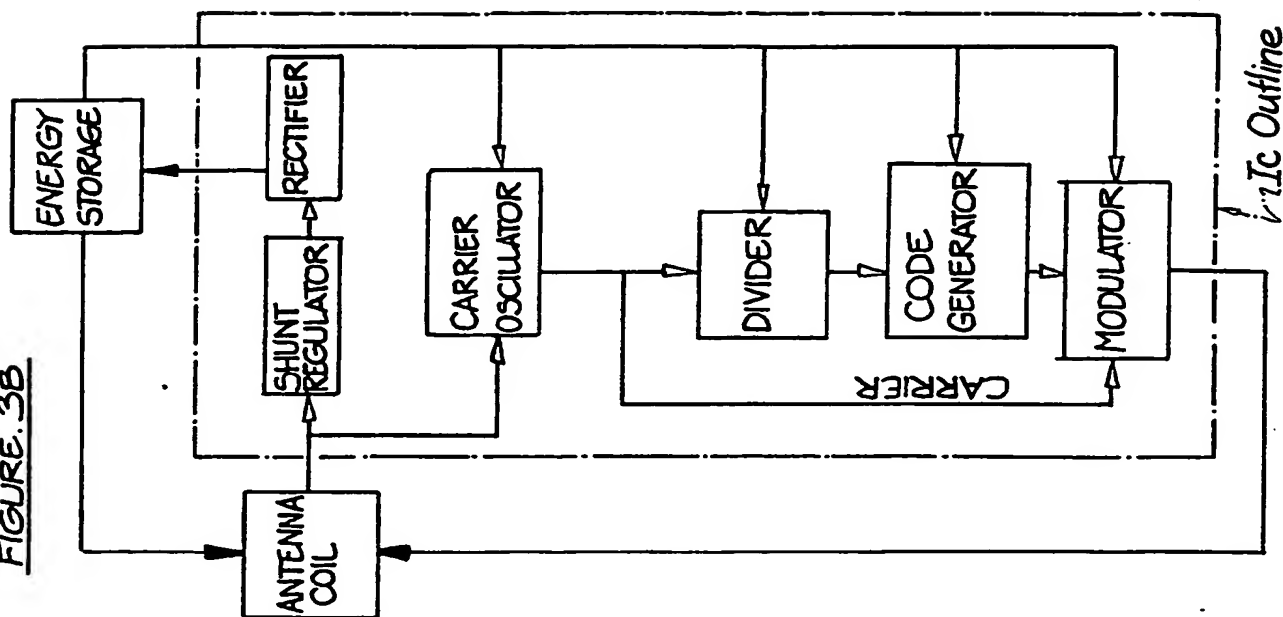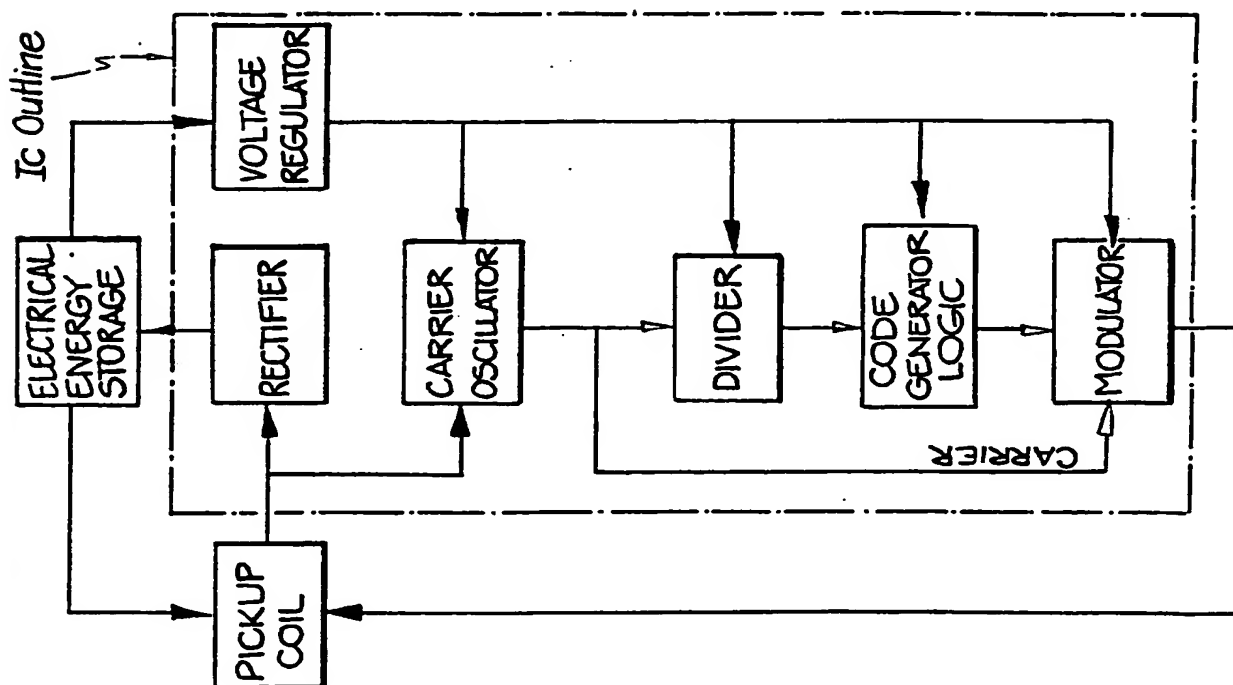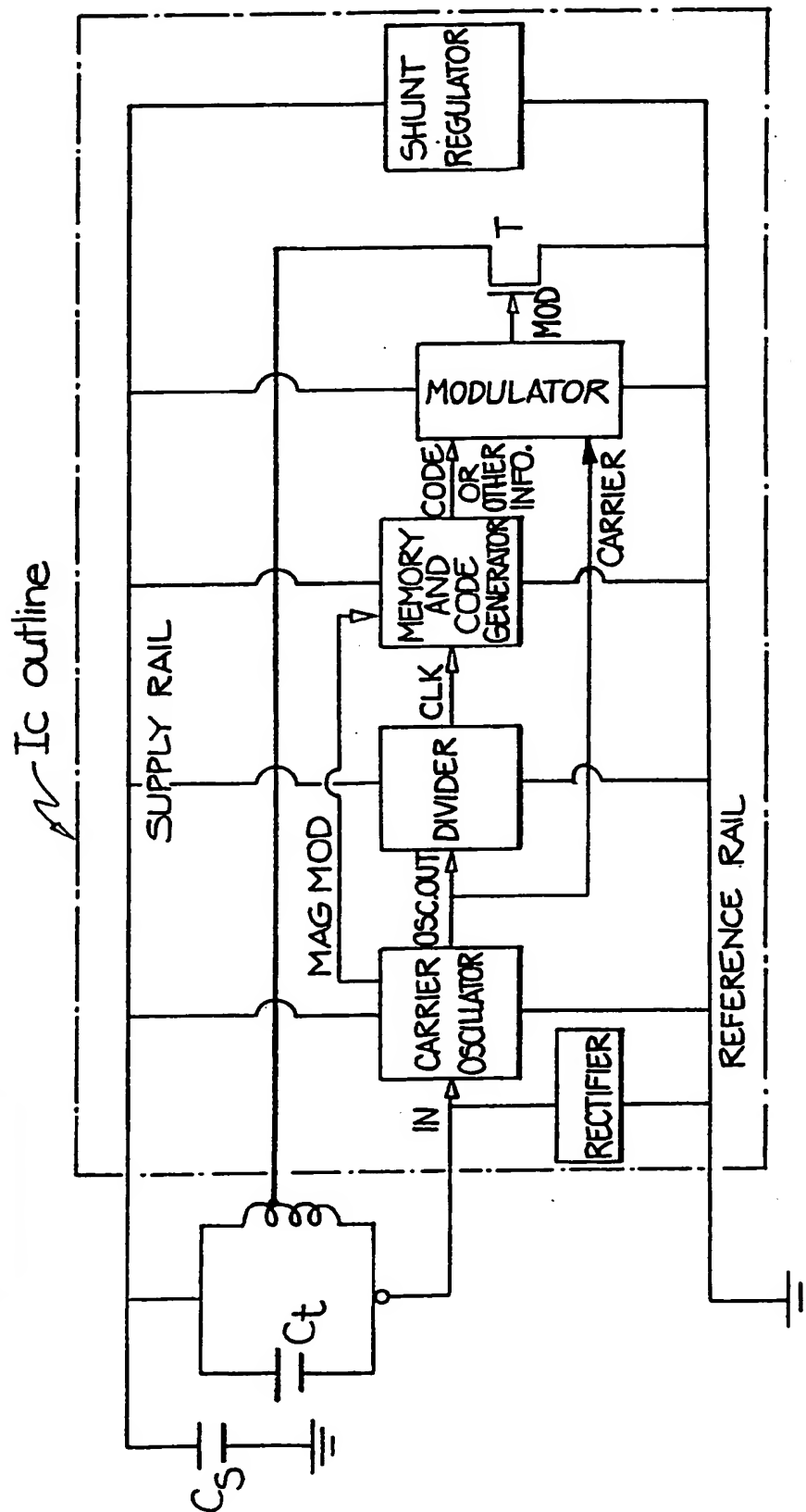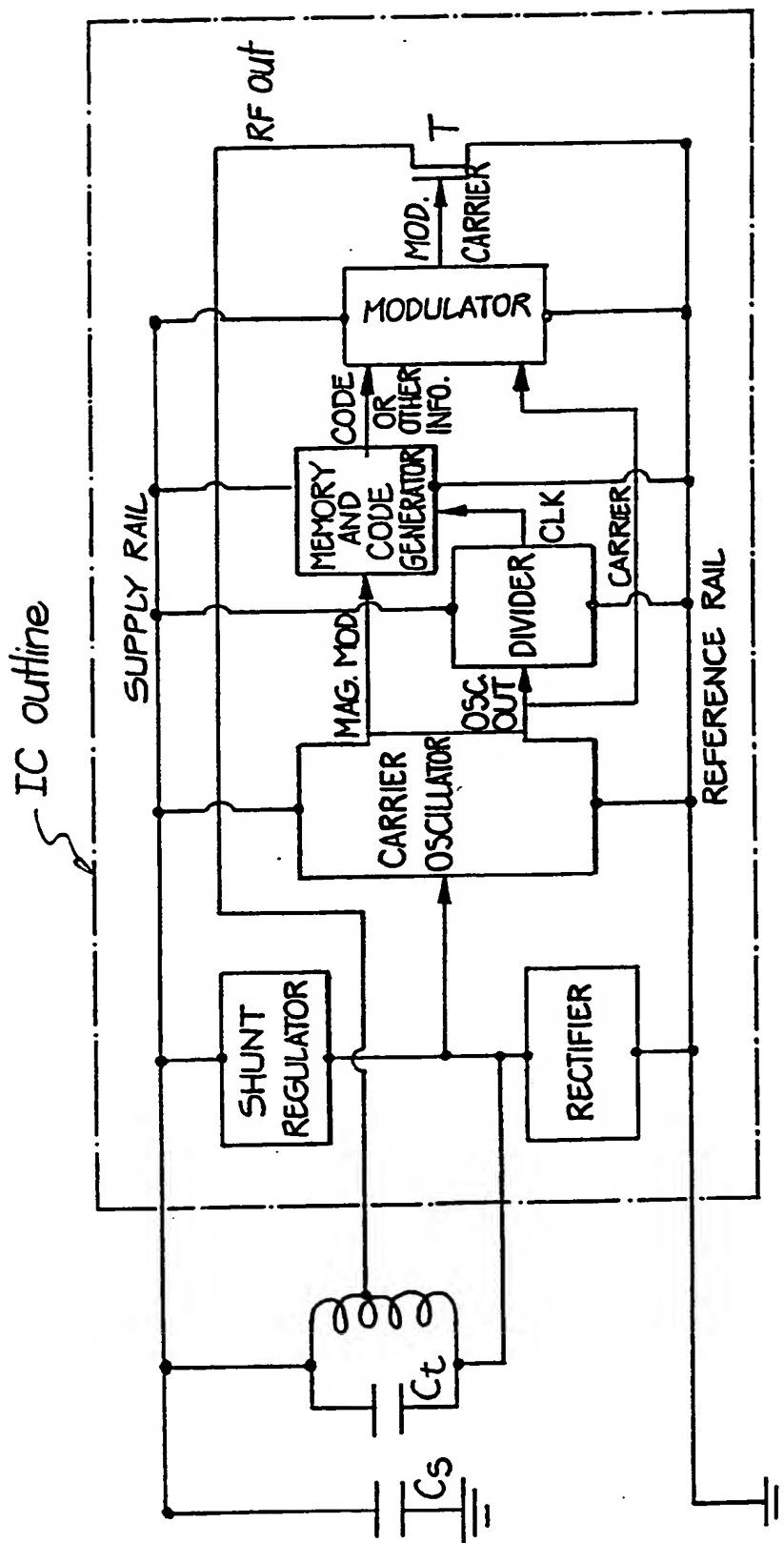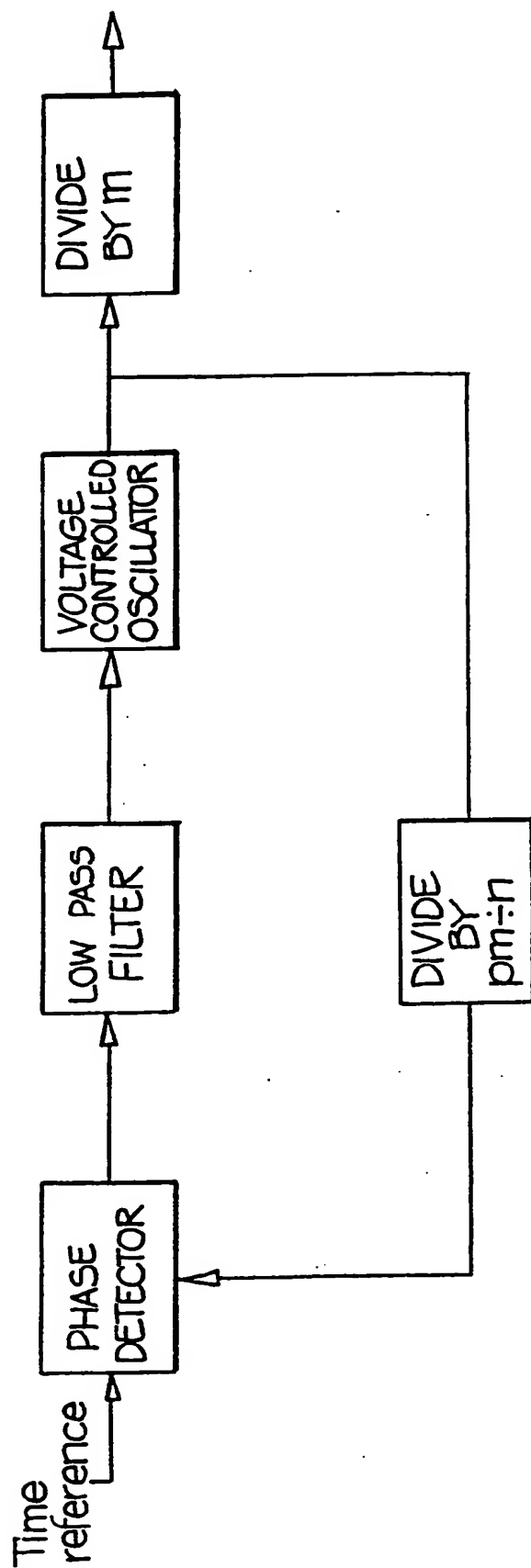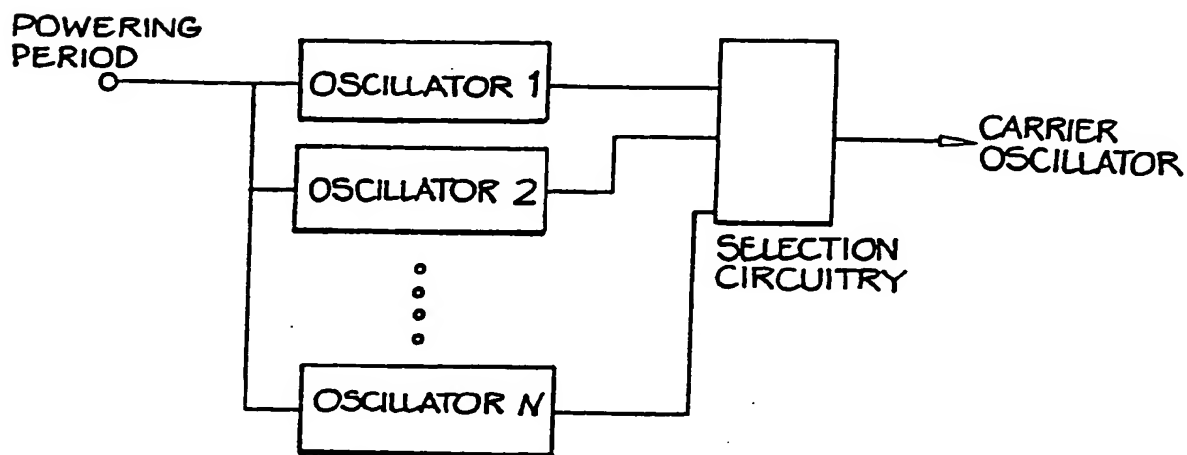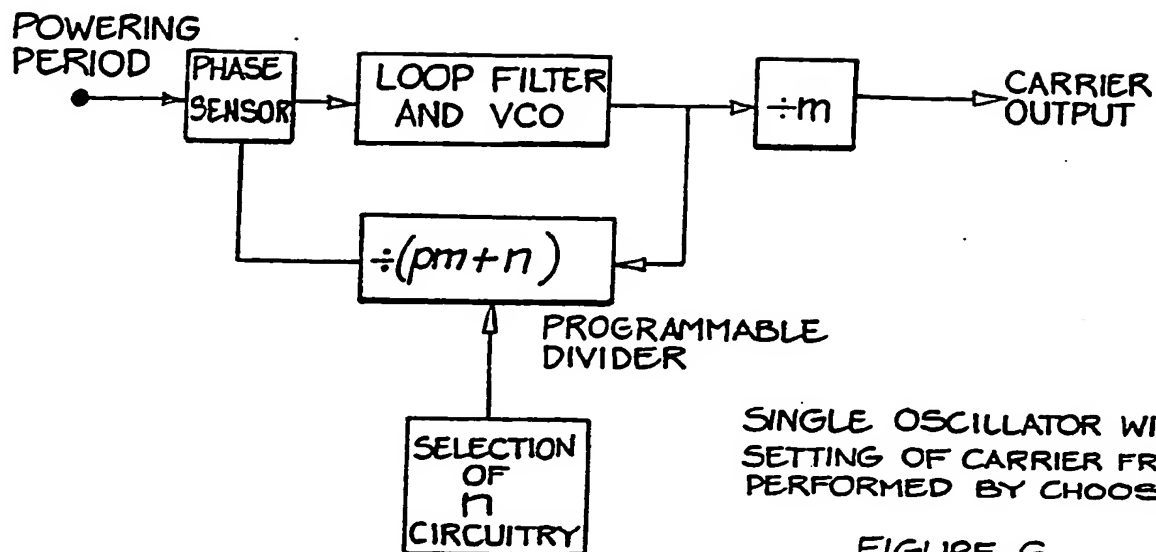
FIGURE. 6



INDIVIDUAL PRESET OSCILLATORS, CARRIER FREQUENCY
SELECTED BY CHOOSING OUTPUT FROM (AT LEAST)
ONE OSCILLATOR

FIGURE. 7

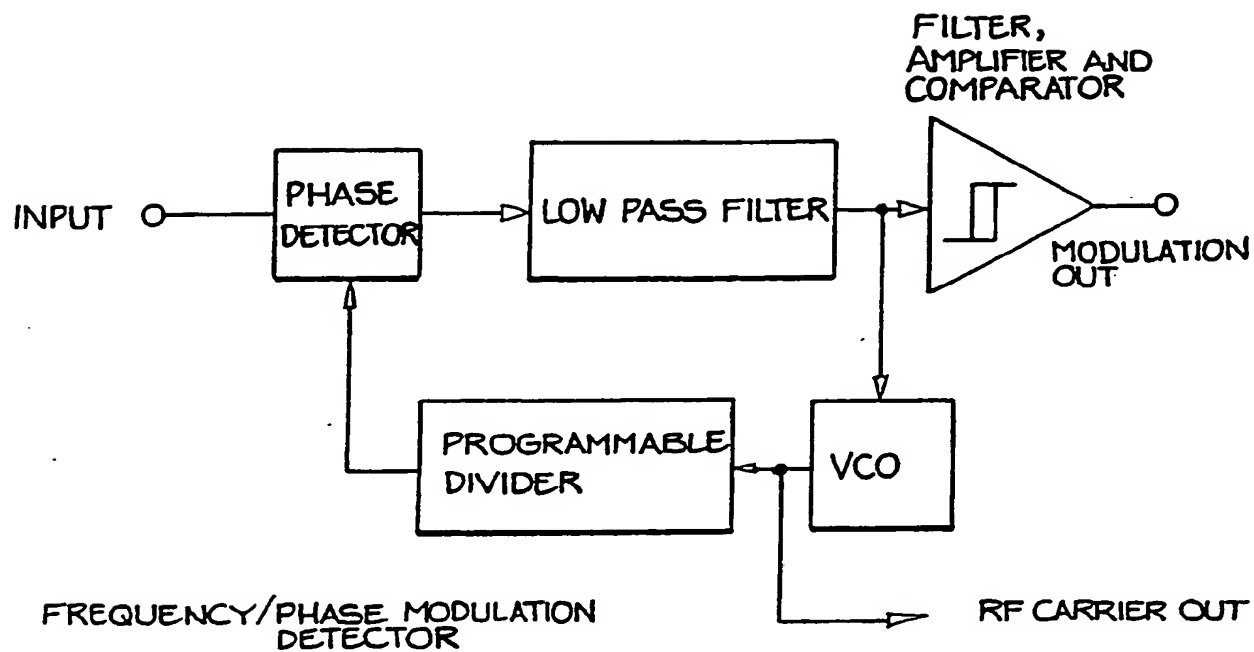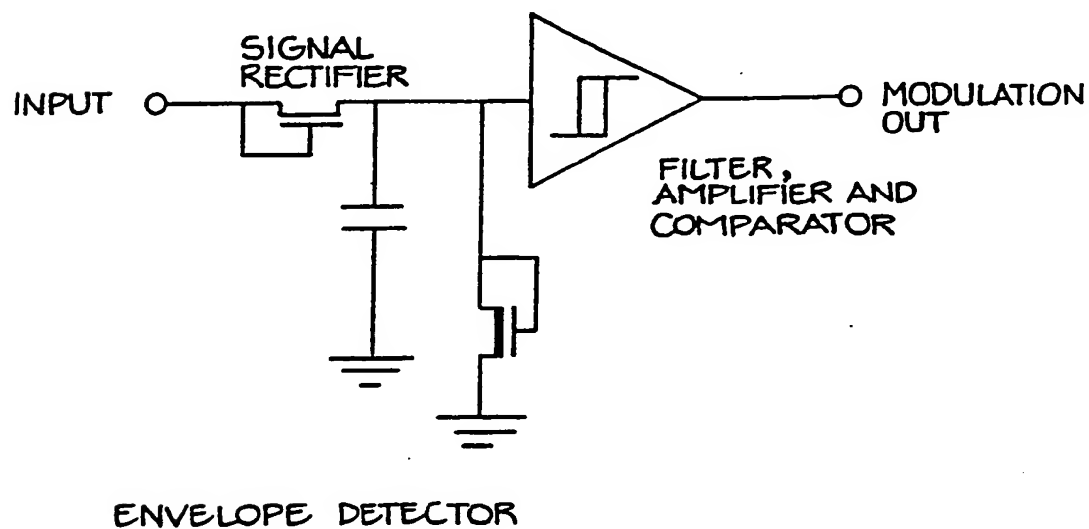$$I_{OUT} = m \times (I_1 + I_2 + \ldots + I_n)$$

$m$ — MIRROR CURRENT GAIN

RECTIFIER

FIGURE.8A

FIGURE.8B

RECTIFIER

CONTROLLED CURRENT SOURCE

DATA INPUT

WAVE SHAPER

RF SIGNAL

RECTIFIER

FIGURE 10A

DATA INPUT

SHIFT REGISTER

n    3 2 1

n SHIFTS PER BIT

RAISED COSINE WEIGHTED CURRENT SOURCE

RF SIGNAL

RECTIFIER

FIGURE.10B

FIGURE.9

FREQUENCY/PHASE MODULATION DETECTOR

FIGURE. 11



ENVELOPE DETECTOR
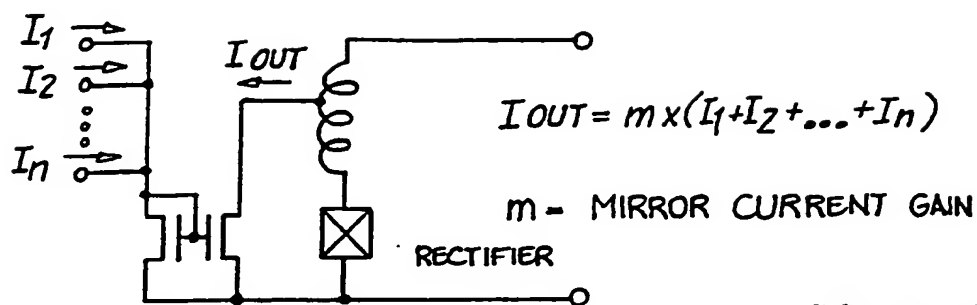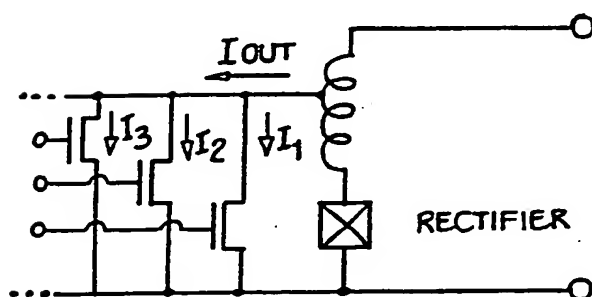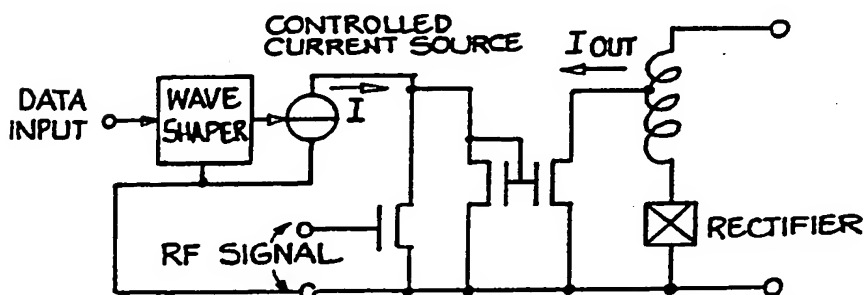
FIGURE. 12

# INTERNATIONAL SEARCH REPORT

International Application No **PCT/AU 88/00469**

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.$^4$    HO4B 1/59, 5/00, G08C 19/28

## II. FIELDS SEARCHED

### Minimum Documentation Searched

| Classification System | Classification Symbols |
|---|---|
| IPC | HO4B 1/59, 5/00, 5/02, 5/04 |

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched

AU :   IPC as above; Australian Classification 05.50

## III. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of Document, with indication, where appropriate, of the relevant passages | Relevant to Claim No. |
|---|---|---|
| X<br>Y | GB,A, 2163324 (ELECTROMATIC PROPRIETARY LIMITED SOUTH AFRICA) 19 February 1986 (19.02.86) | (10,11)<br>(1,15) |
| X<br>Y<br>A | GB,A, 2164825 (SATELLITE VIDEO SYSTEMS LTD.) 26 March 1986 (26.03.86) | (10,11)<br>(1,15)<br>(16.18) |
| X<br>Y | US,A, 3964024 (HUTTON & KRAMER) 15 June 1976 (15.06.76) | (10,11)<br>(1) |
| X<br>Y<br>A | AU,B, 45334/85 (572321) (SENELCO LIMITED) 29 January 1987 (29.01.87) | (10,11)<br>(1,15)<br>(16.18) |
| X<br>Y | AU,A, 55902/86 (GENERAL ELECTRIC CO.) 16 October 1986 (16.10.86) | (10,11)<br>(1,15) |
| X,P<br>Y<br>A | AU,A, 77512/87 (B.I. INCORPORATED) 28 January 1988 (28.01.88) | (10,11)<br>(1,15)<br>(16,18,19) |

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

## IV. CERTIFICATION

| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report |
|---|---|
| 7 March 1989 (07.03.89) | 16 MARCH 1989 (16.03.89) |

| International Searching Authority | Signature of Authorized Officer |
|---|---|
| Australian Patent Office | R. TOLHURST |

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

**V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]**

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers _____, because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claim numbers _____, because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out, specifically:

3.☐ Claim numbers _____, because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

**VI.☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]**

This International Searching Authority found multiple Inventions in this International application as follows:

(1) An arrangement principally characterised by the transponder being powered by a local induction field.

(2) An arrangement principally characterised by the transponder selecting transmit frequencies from a set according to some rule.

1.☒ As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the International application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the International application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

**Remark on Protest**

☐ The additional search fees were accompanied by applicant's protest.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (supplemental sheet (2)) (January 1985)

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | Patent Family Members | | | | | |
|---|---|---|---|---|---|---|
| GB 2163324 | AU 46197/85 | GB 8420893 | GB 8520476 |
| | GB 8813075 | GB 2208058 | ZA 8506178 |
| GB 2164825 | GB 8522951 | | |
| US 3964024 | CA 1055588 | GB 1505093 | IT 1055677 |
| AU 55902/86 | EP 198642 | ES 553816 | ES 8900072 |
| | GB 8509135 | GB 8607588 | GB 2173623 |
| | GB 8817688 | GB 2208025 | JP 62001052 |
| | NO 861353 | | |
| AU 77512/87 | EP 274526 | WO 8800785 | US 4724427 |

END OF ANNEX/CONTINUED